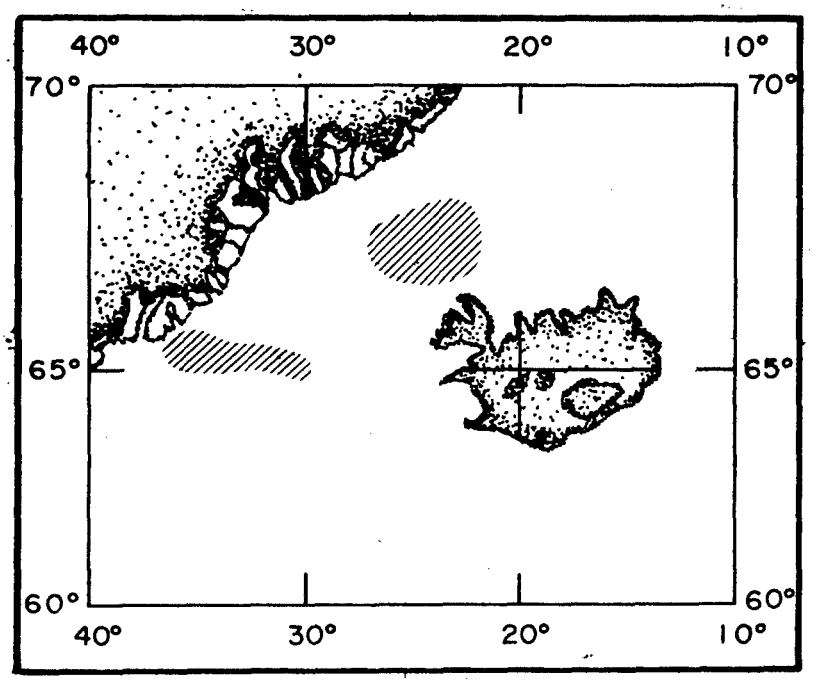
IR NO. 68-37



INFORMAL REPORT

# OCEANOGRAPHIC CRUISE SUMMARY
# DENMARK STRAIT
# APRIL-MAY 1965




JULY 1968



NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

# INFORMAL REPORT

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ABSTRACT

This report describes an oceanographic survey conducted in the Denmark Strait aboard USS EDISTO (AGB 2) during the period 18 April to 8 May 1965.

A strong Arctic outflow was observed near the Greenland coast with speeds up to 30 cm/sec. Between this outflow and the warmer Irminger Current, a pronounced temperature and salinity gradient existed.

The stations occupied in the northeastern part of the strait were separated into two groups displaying similar distribution patterns of physical properties. The western group exhibited a subsurface layer of cooler and less saline waters than the eastern group. This occurrence may be attributed to mixing of Arctic outflow and Return Atlantic Waters to greater depths.

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This report has been reviewed and is approved for release as an UNCLASSIFIED Informal Report.

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CONTENTS



FIGURES



TABLES

## I. PREVIOUS KNOWLEDGE OF THE REGION

The Naval Oceanographic Office (NAVOCEANO) conducted an oceanographic survey in the Denmark Strait area from 18 April to 8 May 1965.

Previous work done in the Denmark Strait area is tabulated in the National Oceanographic Data Center (NODC) publication C-3 (1966). Records show that before 1966, excluding data from this survey, only 38 stations have been occupied in this area during the colder months.

Although the surface layers are affected by seasonal changes, the available data indicate only slight seasonal variation in the subsurface layers.

Figure 1 shows a general scheme of the currents in Denmark Strait. The East Greenland Polar Current is of Arctic origin and is characterized by low salinities and near-freezing temperatures. The current flows southward over the Greenland continental shelf.

The Return Atlantic Current flows under the East Greenland Polar Current, and a major portion turns eastward upon confronting the Greenland-Iceland Ridge. The Return Atlantic Current has an average salinity of about 34.95 ‰ and temperatures from 0° to 2°C.

The Irminger Current has a northern offshoot which courses northward along the western coast of Iceland and then turns eastward along with the Return Atlantic Water. The Irminger Current is primarily Atlantic Water with salinities greater than 35 ‰ and temperatures greater than 4°C (Sverdrup, Johnson, and Fleming, 1942).

Recent work (Harvey, 1961) has produced evidence of Norwegian Sea Deep Water (34.92 ‰ $< 0$°C) overflowing the Greenland-Iceland Ridge.

## II. OBJECTIVES OF THE SURVEY

The mission of the survey was to evacuate personnel from ice island ARLIS II employing USS EDISTO (AGB 2). NAVOCEANO requested ship time on an opportunity basis to collect oceanographic data in the Denmark Strait. Oceanographic stations were planned in order to investigate seasonal differences in temperatures, salinities, dissolved gases, and nutrients.

## III. NARRATIVE OF THE SURVEY

On 15 April 1965, scientific personnel boarded EDISTO in Keflavik, Iceland. Investigations were conducted in the survey area from 18 April to 8 May. The scientific party departed EDISTO in Keflavik on 15 May 1965.

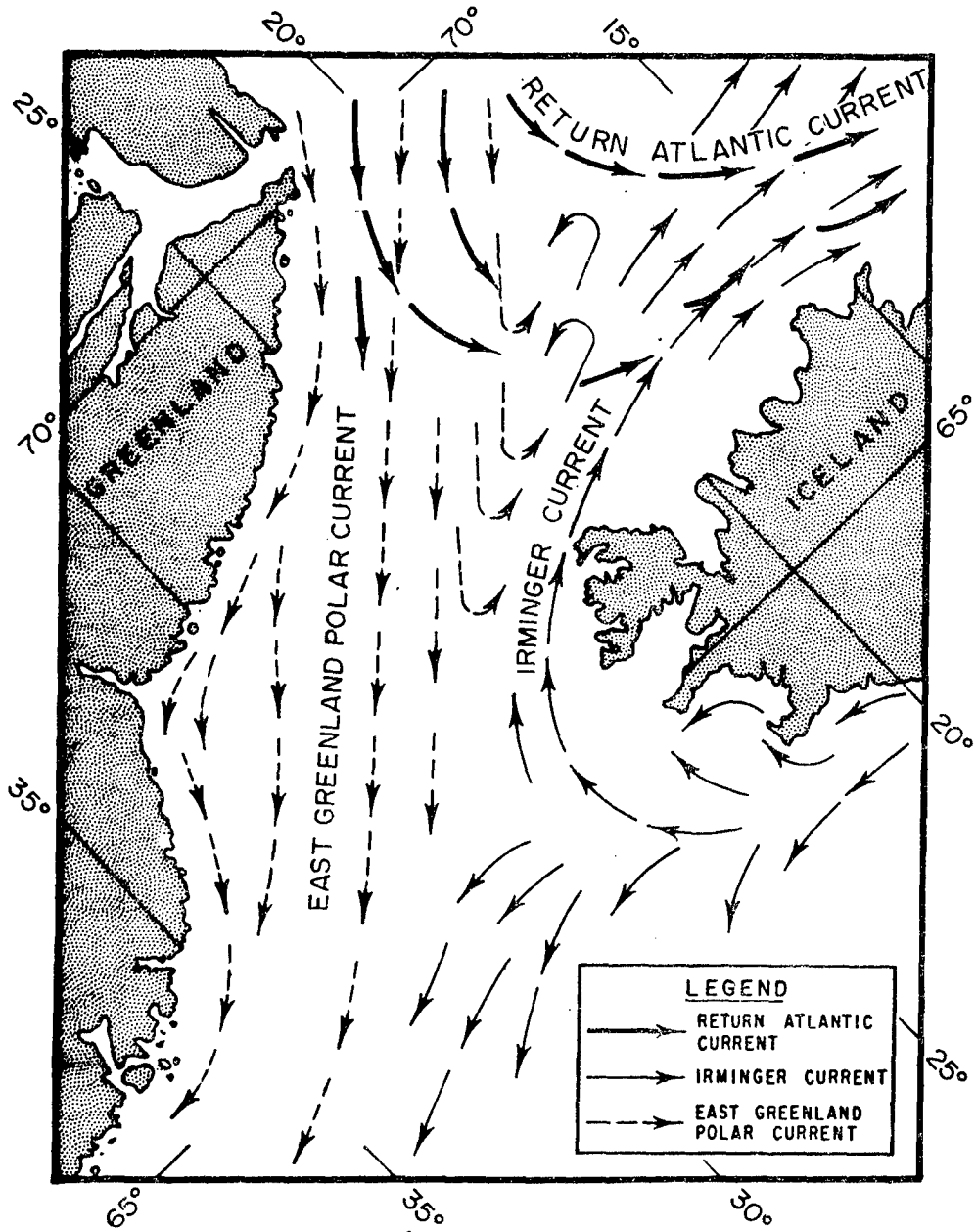


FIGURE 1. CURRENTS IN THE DENMARK STRAIT AREA
(after HO Pub No 705)

Nansen cast observations were taken at 36 oceanographic stations (Fig. 2). Serial depth temperatures and water samples were obtained. Of these water samples, 485 were analyzed for salinity, 190 for dissolved gases, 237 for pH, and 434 were frozen for later nutrient analyses. Table I presents a summary of data collected.

## IV. METHODS OF COLLECTION AND ANALYSIS

### A. Physical Oceanography.

1. Temperature. Water temperatures were measured at selected depths by paired deep sea reversing thermometers attached to Nansen bottles. Thermometer readings were corrected by standard procedures. The accepted temperature values were obtained by averaging the two readings if the values differed by 0.06°C or less. When paired thermometers differed by more than 0.06°C, the reading from the thermometer considered more reliable, based on its previous performance record, was used.

2. Depth. Depth determinations were based on wire out, wire angle measurements, and unprotected deep sea reversing thermometers paired with protected thermometers.

### B. Chemical Oceanography.

1. Salinity. Salinity samples were analyzed aboard ship with an Industrial Instruments portable induction salinometer (Model RS-7B). This instrument is capable of measuring salinity with an accuracy of $\pm$0.01‰.

2. Dissolved Gases. Dissolved oxygen and nitrogen samples were analyzed aboard ship with a modified Fisher-Hamilton Model 29 Gas Partitioner (Swinnerton & Sullivan, 1962). This instrument was coupled with a Texas Instrument Model PWSN Integrating Recorder.

3. Nutrients. Nutrient samples were analyzed in the NAVOCEANO chemistry laboratory for reactive phosphorus according to the method described by Murphy and Riley (1962), and for reactive silicate and nitrate contents according to the methods of Strickland and Parsons (1965).

4. pH. pH measurements were made aboard ship with a Beckman pH meter. The instrumental accuracy of the pH meter is $\pm$.03.

## V. DISPOSITION OF DATA

Temperature, salinity, dissolved gases, nutrient, and pH data for observed depths were returned to NAVOCEANO and prepared for computer processing. The data then were forwarded to NODC and are on file under cruise reference number 31828.

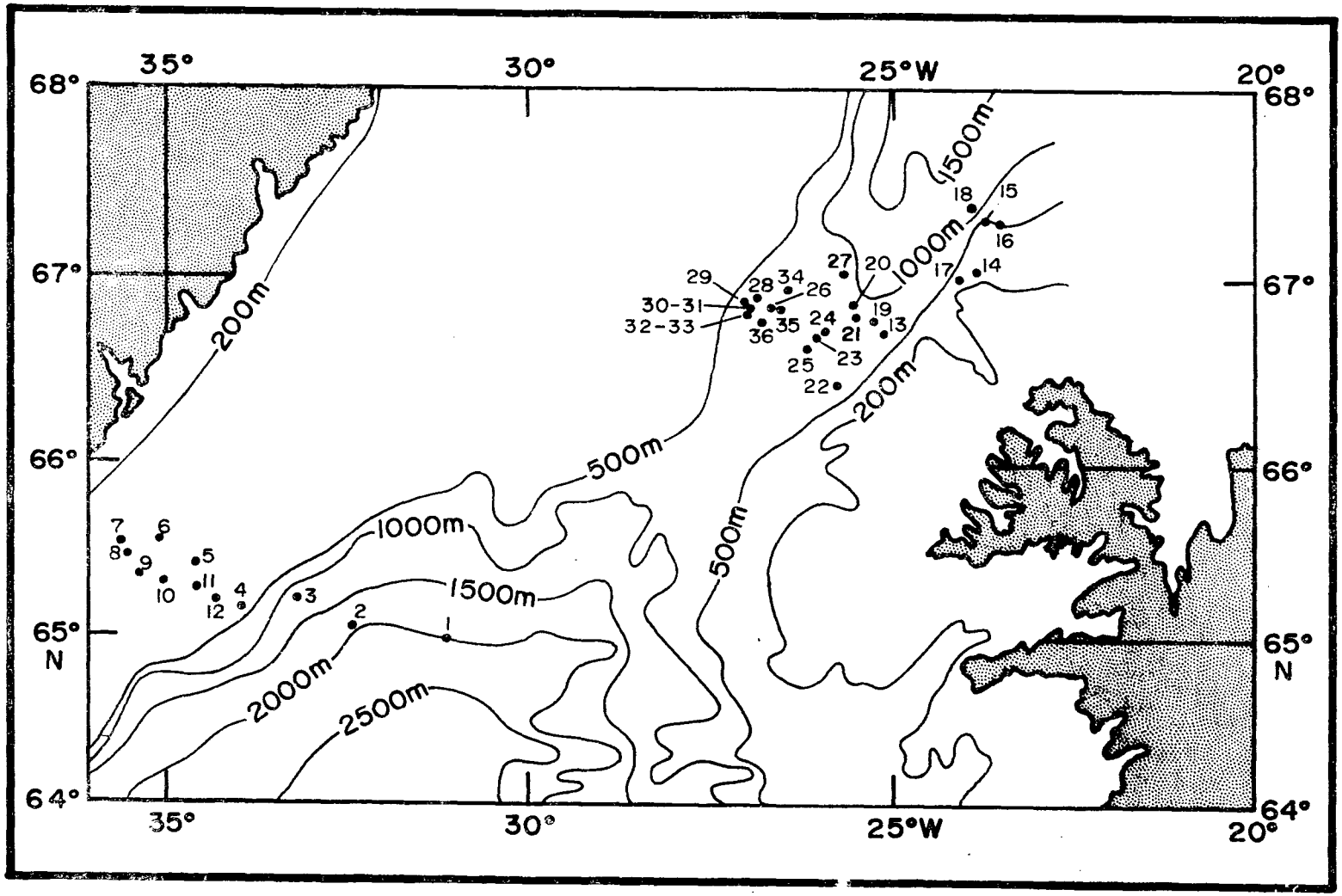


FIGURE 2. BATHYMETRY AND STATION LOCATIONS

TABLE 1. STATION DATA SUMMARY

| Sta. No. | Depth (m) | Sample Depth (m) | Temp. Sal. | Dissolved Gases | Nutrients | pH |
|---|---|---|---|---|---|---|
| 1 | 2058 | 1712 | √ | | √ | √ |
| 2 | 1829 | 639 | √ | √ | √ | √ |
| 3 | 1242 | 1193 | √ | √ | √ | |
| 4 | 346 | 325 | √ | √ | √ | √ |
| 5 | 247 | 223 | √ | √ | √ | √ |
| 6 | 298 | 289 | √ | √ | √ | √ |
| 7 | 219 | 218 | √ | | | |
| 8 | 274 | 252 | √ | | | |
| 9 | 265 | 250 | √ | √ | √ | √ |
| 10 | 219 | 200 | √ | | √ | |
| 11 | 296 | 260 | √ | | √ | |
| 12 | 283 | 249 | √ | √ | √ | |
| 13 | 630 | 600 | √ | √ | √ | √ |
| 14 | 201 | 149 | √ | | √ | √ |
| 15 | 360 | 250 | √ | | | |
| 16 | 402 | 352 | √ | √ | √ | √ |
| 17 | 493 | 392 | √ | √ | √ | |
| 18 | 1463 | 940 | √ | | | |
| 19 | 786 | 584 | √ | | √ | |
| 20 | 732 | 350 | √ | | √ | √ |
| 21 | 706 | 684 | √ | | √ | √ |
| 22 | 704 | 350 | √ | | √ | |
| 23 | 476 | 450 | √ | | √ | √ |
| 24 | 640 | 640 | √ | | √ | √ |
| 25 | 638 | 600 | √ | | √ | |
| 26 | 594 | 550 | √ | | √ | √ |
| 27 | 640 | 596 | √ | | √ | |
| 28 | 540 | 498 | √ | | √ | √ |
| 29 | 516 | 460 | √ | | √ | |
| 30 | 503 | 450 | √ | | | |
| 31 | 512 | 450 | √ | | | |
| 32 | 512 | 450 | √ | | | |
| 33 | 494 | 450 | √ | | √ | √ |
| 34 | 594 | 550 | √ | | √ | |
| 35 | 615 | 150 | √ | | √ | |
| 36 | 457 | 391 | √ | | √ | √ |

## VI. PRELIMINARY ANALYSES

The southern group of stations, shown in Figure 2, was dominated by Polar Water at the western stations and Atlantic Water at the eastern stations. East Greenland Polar Water was most pronounced at stations 7 and 8 (Fig. 3), by temperatures below -1.7°C and salinities less than 34 ‰.

A strong horizontal gradient existed between the Polar Water and the warmer, more saline water of the Irminger Current (Fig. 3). Temperatures increased from less than -1°C at station 8 to greater than 5°C at station 9. The corresponding salinities varied from less than 33.4‰ to greater than 34.8‰.

Geostropic currents were computed using the 250-meter reference level between stations 8 and 9 (Fig. 4). Even though the selected reference was fairly shallow, these calculations indicated a southward flow with speeds in the range expected of the Polar Current as given by Sverdrup, et al (1942).

Warm, saline Atlantic Water was observed at stations 1 through 3 and was present probably due to the influence of the Irminger Current.

The northern stations were occupied while the ship was attempting to reach ARLIS II. The station locations pattern is random since the ship alternately progressed through and drifted with the ice.

Below a thin surface layer (Fig. 5), Atlantic water was observed down to 300 meters at stations 13 and 14. Below the core of Atlantic Water, temperatures decreased, and at 600 meters the temperatures were below 0°C indicating the presence of Norwegian Sea Bottom Water.

Temperature and salinity profiles at stations 19 through 36 fell into two families, represented as mean curves in Figure 6, with the following features:

1. An 80% ice coverage maintained the surface layers (upper 100 meters) near the freezing point.

2. The higher surface salinities occurred at the western-most stations, group B.

3. The subsurface temperature maximum is slightly higher at group A than at group B. This maximum appears to be associated with the Return Atlantic Water.

4. If the lower curves (group B) are raised 50 to 100 meters, they will correspond closely to the upper curve (group A). This suggests that the same water masses are involved. The layer between 100 meters and the temperature maximum is the mixing zone of the Polar outflow and the Return Atlantic Water. The lower set of curves (group B) may indicate mixing to a greater depth.

## VII. ADDITIONAL WORK NEEDED IN THE REGION

Denmark Strait is an important area of water exchange between the Arctic and Atlantic Oceans. Investigations for all seasons would be required to accurately estimate the extent of this exchange. Since Greenland's continental shelf is icebound during winter months, a subsurface current meter array with temperature recorders would be preferred. Such arrays could be planted in the summer and retrieved a year later.

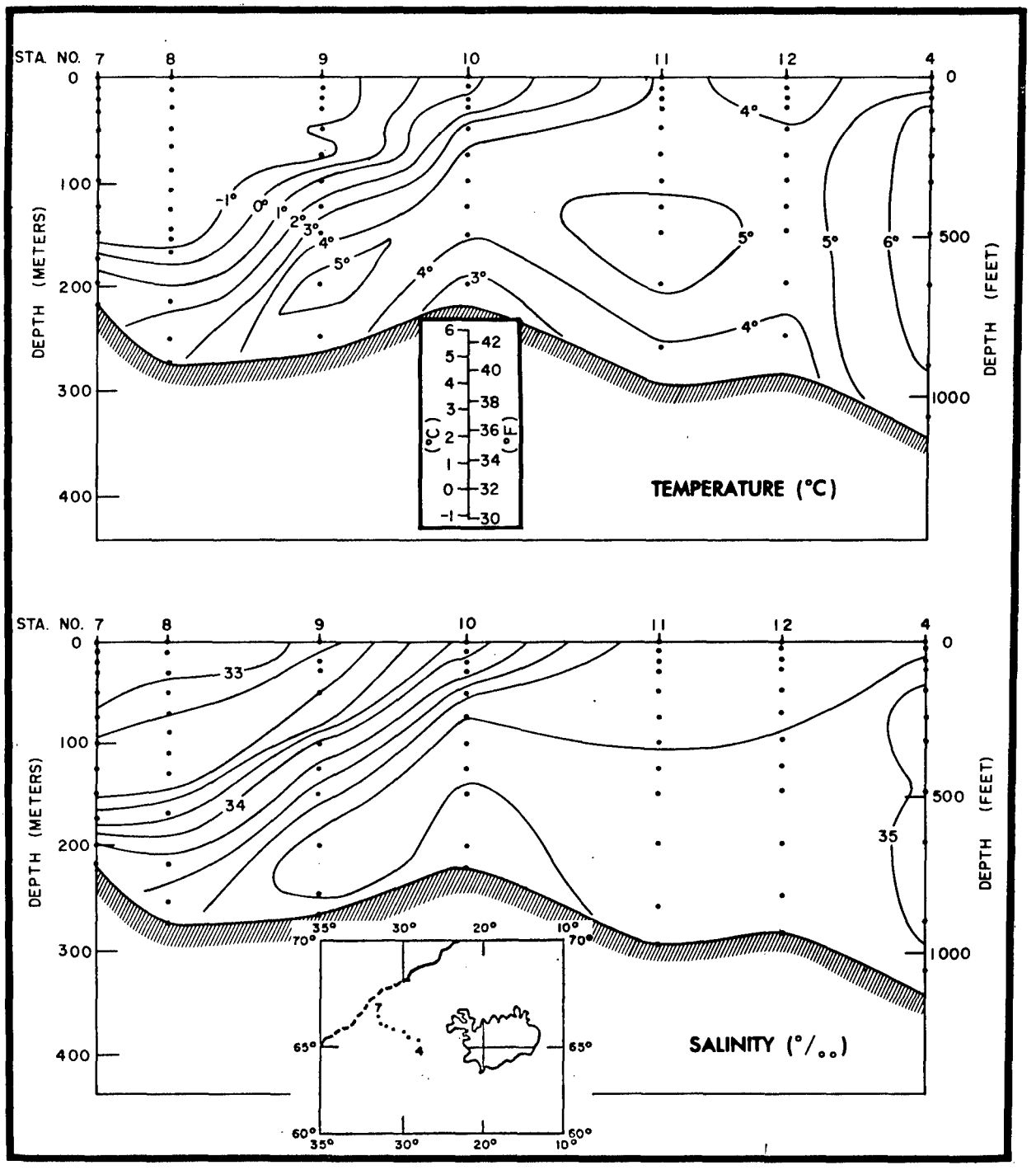


FIGURE 3. TEMPERATURE AND SALINITY CROSS SECTIONS, WEST-EAST

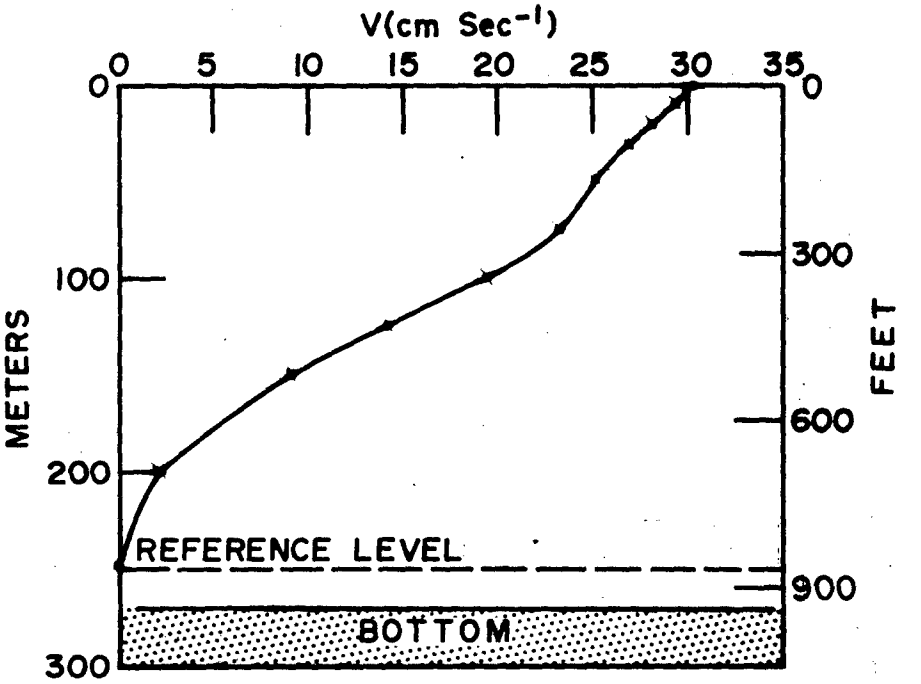


FIGURE 4. GEOSTROPIC CURRENT BETWEEN STATIONS 8 AND 9

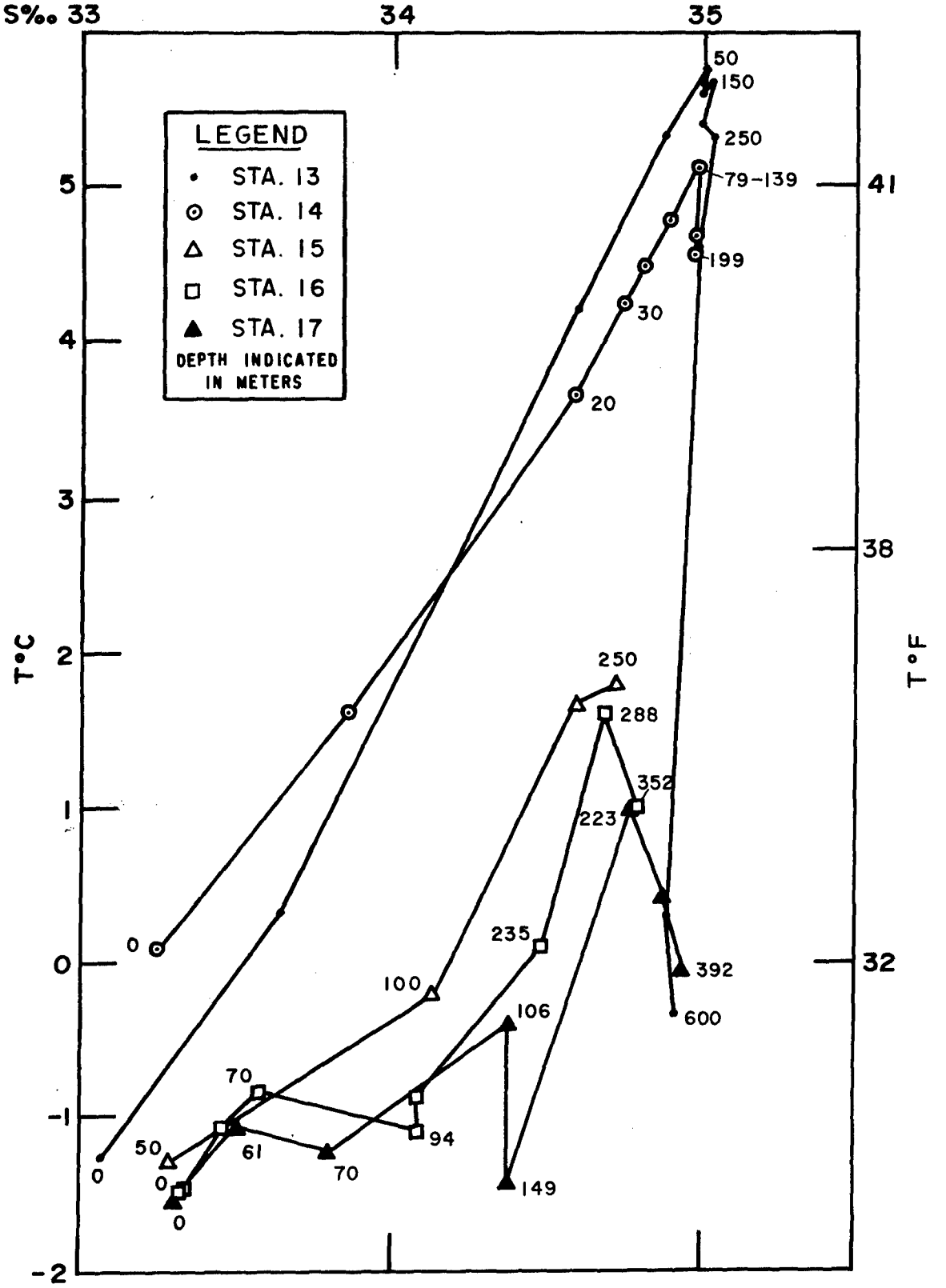


FIGURE 5. TEMPERATURE-SALINITY DIAGRAM

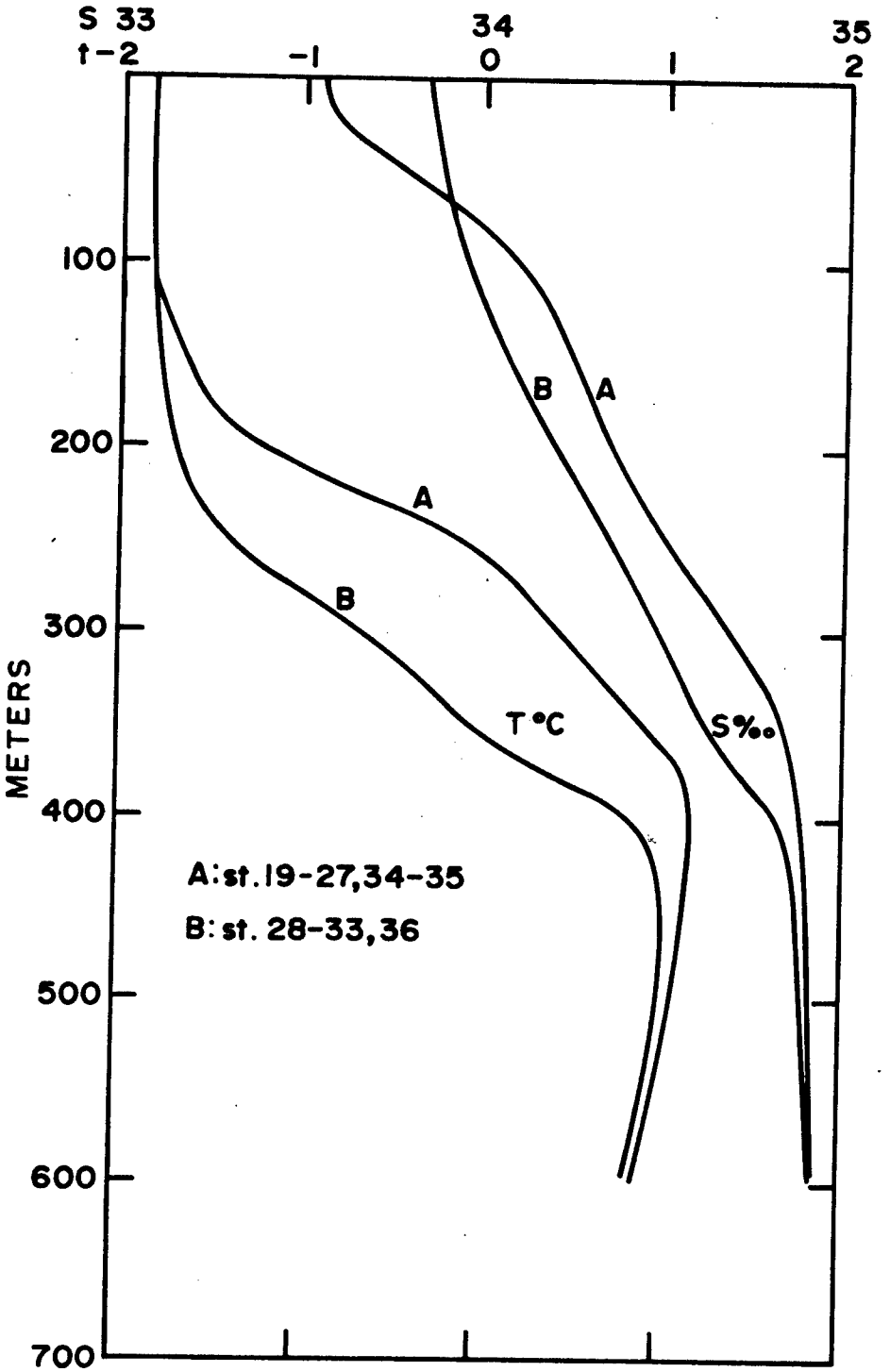


FIGURE 6. TEMPERATURE-SALINITY PLOTS VERSUS DEPTH

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| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| OCEANOGRAPHY<br>DENMARK STRAIT<br>USS EDISTO (AGB 2) | | | | | | |